Appendix A

Hamilton Wetland Restoration Project Description

DRAFT
EXECUTIVE SUMMARY

HAMILTON WETLANDS CONCEPTUAL RESTORATION PLAN

Prepared for

The State Coastal Conservancy
The City of Novato

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Prepared by
Woodward-Clyde
with
H.T. Harvey & Associates
Eric Polson, Consulting Engineer

Philip Williams & Associates, Ltd.

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Woodward-Clyde

Francesca Demgen
Senior Project Scientist, Project Manager

Ulrich Luscher, Ph.D., P.E., G.E.
Geotechnical Engineer

Justin Reginato
Engineering Support

Said Salah-mars, Ph.D., P.E.
Geotechnical Engineer

Jennifer O'Connell
Wildlife Biologist

Peer Reviewers

Tom McDonald, P.E.

Steve Kellogg

Tom Baily

H.T. Harvey

Dan Stephens
Restoration Ecologist, Principal

Eric Webb, Ph.D.
Project Manager

Scott Terrill, Ph.D.
Wildlife Division Head

Mark Jennings, Ph.D.
Aquatic Biologist

Steve Rottenborn, Ph.D.
Wildlife Biologist

Holly Ganz, M.S.
Benthic Ecologist

Eric Polson, Consulting Engineer

Philip Williams & Associates

Phillip B. Williams, Ph.D., P.E.
President and Principal-in-Charge

Rachel Z. Kamman, P.E.
Senior Associate and Project Manager

Michelle K. Orr
Associate and Assistant Project Manager

Brendan DeTemple
Hydrologist

Brad Evans
Graphic Designer

and with

Greg Kamman, R.G., C.H.
Associated Consultant

External Reviewers

Steve Goldbeck
San Francisco Bay Conservation and Development Commission

Terri Nevins
State Coastal Conservancy

Stuart W. Siegel
P.W.S. Principal
Stuart Siegel Wetlands and Water Resources

The California State Coastal Conservancy (Conservancy), with staff support from the San Francisco Bay Conservation and Development Commission (BCDC), is investigating the feasibility of restoration of the former Hamilton Army Airfield and the adjacent State Lands Commission (SLC) Antennae Field to tidal and non-tidal wetlands. This Feasibility Analysis and Conceptual Restoration Plan (Hamilton Conceptual Plan) presents a plan to carry out this proposed wetland restoration project.

The Hamilton Conceptual Plan discusses the project goals and objectives established by the Hamilton Restoration Group (HRG) (Section ES-1), describes the project area (Section ES-2), discusses the development of project alternatives (Section ES-3), presents an ecological and engineering overview of the Preferred Alternative, including a cost estimate (Section ES-4), highlights the differences between the Preferred Alternative and the Natural Sedimentation alternative (Section ES-5), describes the timeline for restoration (Section ES-6), and identifies issues for further consideration during final design (Section ES-7).

The project site is located on the northwestern edge of San Pablo Bay in the San Francisco Estuary (see Figure ES-1). The Hamilton site, totaling over 900 acres, consists of the 619-acre former Hamilton Army Airfield plus the contiguous 20-acre Navy ballfields to the south (together termed the "HAAF parcel"), and the contiguous 250-acre State Lands Commission Antennae Field (termed the "SLC parcel") to the north of HAAF. The HAAF site (excluding the Navy ballfields) is currently owned by the U.S. Army and is proposed to be transferred to the Conservancy following base closure. The Navy ballfields are currently owned by the U.S. Navy and are also proposed to be transferred to the Conservancy. The SLC parcel is currently owned by the State Lands Commission of California.

Wetlands restoration on the portion on the airfield parcel (Figure ES-2) and the adjoining abandoned antennae field that together constitute the project area is consistent with and helps implement applicable local, regional, and state plans, including the Hamilton Reuse Plan, the City of Novato General Plan, and the San Francisco Bay Conservation and Development Commission San Francisco Bay Plan. Restoration is also consistent with several regional initiatives and plans including:

- the San Francisco Estuary Project's Comprehensive Conservation and Management Plan,
- the Regional Habitat Goals Process,
- the Long Term Management Strategy (LTMS) for Dredged Material Disposal
- the CALFED program.

Use of the airfield for aviation would not be consistent with local and regional planning and would be incompatible with the extensive residential development under construction immediately adjacent to the old runway. Therefore, aviation use is not considered in this Conceptual Plan.

In addition, the project will:

- Place the restored wetlands under the long-term management of the U.S. Fish and Wildlife Service or the California Department of Fish and Game.
- Complete the closure, transfer and reuse of the Hamilton Army airfield

- Provide for beneficial use in site construction of over 10 million cubic yards of dredged material from Bay maintenance dredging and new deepening projects that otherwise would likely be disposed as a waste in the Bay or ocean
- Use freshwater runoff from surrounding properties to enhance habitat diversity
- Improve local flood protection
- Provide for public access

ES-1.1 PROJECT GOALS AND OBJECTIVES

The Hamilton Restoration Group (HRG), an advisory group including the City of Novato; local, state and federal resource and regulatory agencies; the U.S. Army; adjacent landowners; concerned individuals; non-profit groups, and the business and dredging community was central to the development of the conceptual plan. The design team, consisting of staff of the Coastal Conservancy, BCDC, and the consultants, worked with the HRG to develop the project goal and objectives as described in the following sections.

ES-1.1.1 Goal

The goal of the Hamilton Wetland Restoration Project is to create a diverse array of wetland and wildlife habitats at the Hamilton site that benefits a number of endangered species as well as other migratory and resident species.

ES-1.1.2 Ecological Objectives

- Creation of a mix of tidal habitats on 80 percent of the land area available for restoration. This mix will consist of subtidal open water, intertidal mudflats, low, middle and high intertidal marsh, channels, interior tidal ponds, and tidal pannes, with the relative amount of each type changing over time as the site evolves following restoration.
- Creation of a mix of nontidal habitats on 20 percent of the land area available for restoration. If this is not feasible, at least the minimum acreage necessary to replace existing seasonal wetlands on the site at a 1:1 ratio (about 8 percent) will be created. This mix will consist of shallow seasonal ponds and wetlands, and a limited amount of grassland and upland.

ES-1.1.3 General Objectives

- To design and engineer a restoration project that stresses simplicity and has little need for active management
- To demonstrate beneficial reuse of dredged material, if feasible
- To recognize existing site opportunities and constraints, including the runway and remediation of contaminated areas, as integral components of design
- To ensure no net loss of wetland habitat functions presently provided at the Hamilton site

- To create and maintain wetland habitats that sustain viable wildlife populations, particularly for Bay Area special status species
- To include buffer areas along the upland perimeter of the project area, particularly adjacent to residential areas, so that wildlife will not be impacted by adjacent land uses. Perimeter buffer areas should also function for upland refuge, foraging, and corridors for some species
- To be compatible with adjacent land uses and wildlife habitats
- To provide for public access that is compatible with protection of natural resource values and local public access policies.

ES-2.1 SITE DESCRIPTION

Several existing features of the Hamilton site have influenced development of the restoration alternatives and are discussed in this section: drainage conditions and freshwater inflows from adjacent properties, site subsidence, Novato Sanitary District facilities, the runway, existing biological resources, and the potential to expand the project onto the adjacent Bel Marin Keys Unit V property.

ES-2.1.1 Subsidence

The Hamilton site has subsided on average approximately 8 ft. since it was diked off from San Pablo Bay. Much of the site is below -5 ft. NGVD (National Geodetic Vertical Datum of 1929, which is the datum used throughout this report unless otherwise noted). This means that flood control levees will be needed to protect adjoining properties from tidal waters after the project is restored. It also means that imported fill material or interior dikes will be needed to construct site features such as seasonal wetlands or uplands.

ES-2.1.2 Drainage Conditions and Freshwater Inflows

Winter storm flows from several adjacent properties drain into HAAF and are conveyed via the perimeter drainage system to the Army pump station where the water is pumped out into San Pablo Bay. These inflows include two storm water outfalls from the New Hamilton Partners (NHP) development south of HAAF, Landfill 26 south of HAAF, Pacheco Pond storm overflows northwest of HAAF, and some surface drainage from Las Gallinas Valley Sanitary District lands south of HAAF, the SLC parcel and the California Quartet/Bel Marin Keys Unit V property north of HAAF. Most of these inflows will be able to drain through the restored wetlands (pumps may be required for some inflows). However, this Plan assumes that the U.S. Army resolves drainage issues for the adjacent Las Gallinas Valley Sanitary District lands to the south and the Bel Marin Keys Unit V property to the north

ES-2.1.3 Novato Sanitary District Facilities

The Novato Sanitary District (NSD) has two existing facilities on the SLC site: (1) an outfall pipe that crosses the site to the north of the boundary between the HAAF and SLC parcels and has a shallow water discharge approximately 900 feet offshore in San Pablo Bay, and (2) a dechlorination plant located about 1,300 feet west of the outboard levee (Figure ES-2). Utilities and an access road to these facilities are also present The Dechlorination plant and associated utilities are proposed to be relocated off the project site.

ES-2.1.4 Runway

The now-abandoned runway slopes gently downward from the northwest to the southeast and extends over the length of the southern side of HAAF. It is below sea level and estimated to be approximately 3-ft. thick concrete, so it will be buried in place.

ES-2.1.5 Existing Biological Resources

There are approximately 19.5 acres of existing seasonal wetlands on the HAAF parcel (including the 12.4 acre Landfill 26 mitigation site). Another 16 acres of seasonal wetlands are located on the SLC parcel. The perimeter drainage ditch contains another 1.2 acres of brackish marsh. Most of the HAAF site is grassland. There are approximately 120 acres of pickleweed (*Salicornia virginica*)-dominated tidal marsh on the bayward side of the outboard levee that separates the site from San Pablo Bay. Several special status species are known to occur at the site. Four species (California clapper rail, California black rail, San Pablo song sparrow, and salt marsh common yellowthroat) utilize the outboard tidal marsh. It is assumed that the salt marsh harvest mouse is also utilizing the outboard tidal marsh. Three other species (northern harrier, short-eared owl, and burrowing owl) use the wetlands and grasslands for foraging and/or nesting.

ES-2.1.6 Potential Project Expansion

The Conservancy is engaged in discussions with the owners of the Bel Marin Keys (BMK) Unit V property (see Figure ES-2) for possible inclusion in this restoration project. The BMK site is approximately 1,610 acres. Addition of this parcel would obviate the need for a flood control levee along the northern perimeter of the HAAF and SLC parcels, though a flood control levee would be required further to the north.

ES-3.1 DEVELOPMENT OF THE PROJECT ALTERNATIVES

The design team together with the HRG initially generated four alternatives and narrowed these down to two alternatives (alternatives 1 and 2) for consideration in the Feasibility Analysis. Alternative 1, the Natural Gradient alternative, is the Preferred Alternative because it is the only alternative that meets all the project objectives. The Preferred Alternative is the subject of the Conceptual Restoration Plan. Alternative 2, the Natural Sedimentation alternative, is a viable approach that can be implemented if adequate volumes of dredged material are not available. Briefly, these alternatives are:

- Alternative 1 (Preferred Alternative): Natural Gradient. This alternative would restore a combination of tidal wetlands and nontidal wetlands and upland habitats that would drop in elevation from the upland perimeter down to San Pablo Bay. This alternative would utilize dredged material to raise site elevations to restore the non-tidal wetlands above the tidal plain and to accelerate formation of tidal wetland in areas that will be subject to tidal action. Section ES-4 describes this alternative in more detail.

- Alternative 2: Natural Sedimentation (Backup Alternative). This alternative consists of breaching the outboard levee and allowing natural sedimentation to restore tidal wetlands on the site. Two variations were considered: (1) tidal action would be restored to the entire site, and (2) a new levee would preclude tidal action from a portion of the site where nontidal wetlands would be restored. The design team and the HRG carried the second variation forward in the Feasibility Analysis. Section ES-5 describes the differences between this alternative and the Natural Gradient alternative.

- Alternative 3: Historic Condition (Incorporated Into Alternatives 1 and 2). This alternative would restore the historic condition at the site, based on maps from the mid-1800s: large numbers of interior tidal ponds intermixed within a vast expanse of intertidal marsh. This alternative would not provide seasonal wetlands and it would be difficult to construct interior tidal ponds. However, both the alternatives carried forward are expected to restore interior tidal pond features through natural processes.

- Alternative 4: Seasonal and Tidal Wetland (Dropped from Further Consideration). This alternative would restore tidal and nontidal wetlands. A levee would separate the nontidal wetlands, which would be created at existing site elevations, from the tidal wetlands, which would be created through placement of dredged material. The design team and the HRG eliminated this alternative based on an analysis that the nontidal wetlands should have priority for construction with dredged material and therefore a separator levee would not be necessary.

ES-4.1 DESCRIPTION OF THE PREFERRED NATURAL GRADIENT ALTERNATIVE

The Natural Gradient alternative is the preferred alternative for restoration at Hamilton because it is the only alternative that meets all the project objectives. This section presents an overview of the conceptual-level design for the Natural Gradient alternative.

ES-4.1.1 Overview of the Natural Gradient Alternative

The Natural Gradient alternative meets the project ecological objectives of 80 percent tidal wetlands and 20 percent nontidal wetlands and uplands. This section describes the ecology, hydrology and geomorphology of the habitats to be restored and it describes how each habitat will change over time due to the natural processes of sediment accretion, subsidence, settlement, and sea level rise. Figure ES-3 shows the layout of this alternative at completion of project construction, and Figures ES-4 and ES-5 show the site after 10 and 50 years, respectively. Table ES-1 summarizes the target habitats for the Natural Gradient alternative. This alternative relies on the site topography to drain water through the site, resulting in a design that minimizes the need for active management and maintenance.

Non-Tidal Habitat

Non-tidal habitat will be located on the northwestern portion of the project site (130 acres) and on the southeastern portion of the site (20 acres) (Figure ES-3). Three habitat types will be constructed with dredged material in these areas: uplands, seasonal ponds and wetlands, and a riparian corridor. However, as the dredged material settles (compacts in place) and subsides (compacts the underlying substrate) and sea level rises over time, the actual acreage of the non-tidal habitat will gradually decrease, with the lower elevations changing to tidal habitats. The seasonal ponds and wetlands will be interspersed across the non-tidal portion of the site as a result of topographic variability.

Uplands

Upland areas will be constructed around the site perimeter and will consist of the flood control levees and a buffer/wildlife corridor area. Upland areas will be vegetated by grasses, shrubs and trees established through natural colonization. Uplands will provide refuge for animals using the tidal wetlands, migratory corridors for animals, foraging habitats for many animals, and roosting and nesting habitats for many bird species such as the Burrowing Owl, Loggerhead Shrike, and Northern Harrier.

Seasonal Ponds and Wetlands

Seasonal ponds and wetlands will be constructed in the panhandle area in the northwestern portion of the HAAF parcel and in the "ballfields" area in the southeastern portion of the HAAF parcel. Formation of seasonal ponds and wetlands would rely on rainfall and flood flows for their water supply.

Water and soil salinities would vary throughout these seasonal wetland and ponded areas, providing for a range of plant community composition and ecological functions. The seasonal wetlands will primarily provide low herbaceous vegetation intermixed with shallow seasonal

ponds and emergent wetland vegetation. The seasonal ponds will be open water areas with vegetated or unvegetated perimeters. These seasonal habitat will be intermixed and their extent and duration will vary from year to year depending on the local climate. The site will provide habitat for shorebirds and migratory waterfowl. Invertebrate abundances will be high, supporting a food web including shorebirds and waterfowl, as well as species normally found in upland grasslands.

Drainage Channel Riparian Corridor

A drainage channel will be constructed to provide gravity drainage for seasonal flows from the NHP outfalls, Landfill 26 and Pacheco Pond through the tidal marsh to San Pablo Bay (Figure ES-3). These channels would bisect the seasonal ponds and wetlands. The drainage channel would have emergent vegetation such as bulrush (*Scirpus* spp.), cattails (*Typha* spp.), and rush (*Juncus* spp.). Additionally, some riparian trees could become established along the drainage channel and form patches of riparian habitat. The riparian shrubs and emergent vegetation will provide habitat for song birds, raptor perching and cover for small mammals.

Evolution of the Non-Tidal Habitat

Three types of evolution are expected in the non-tidal habitats: ecological changes as vegetation and wildlife habitat colonize the new substrate, structural changes as the areas settle and subside and are subject to sea level rise, and hydrologic changes resulting from the structural changes. Ecological changes are likely to include continual changes in the plant community composition as the early pioneer species are augmented and in some cases replaced by secondary species and increases in wildlife use as food web complexity builds over time and migratory and resident wildlife species colonize the areas.

Structural changes will include differential settlement and subsidence of the placed dredged material. Hydrologic changes will result from the structural changes and fall into two categories: (1) depressions that pond water will form across the landscape as a result of the differential settlement, which will define the locations, extent and inundation regimes of the seasonal ponds and wetlands; and (2) as elevations drop and sea level rises, the lower elevations will become subject to infrequent tidal action and begin to develop a hydrologic regime associated with tidal pannes and high tidal marsh (see the next section describing the tidal wetland habitat). Figures ES-4 and ES-5 show the expected distribution of these habitat types ten and fifty years after project construction, respectively, illustrating how the total acreage of these habitats diminishes over time. All these evolutionary changes are considered beneficial and reflect the long-term ecological goals for the Hamilton site.

Tidal Habitat

Tidal habitats will be located on much of the HAAF parcel (428 acres) and on the SLC parcel (250 acres) (Figure ES-3). Six tidal habitat types will be created in this alternative. Intertidal mudflats and tidal pannes will be the initial habitat type when the levees are breached. Tidal marsh channels and subtidal open water will form on and within the intertidal mudflat. Lastly, tidal marsh and interior tidal ponds will form by natural processes as the system evolves over time. The estimated acreages of each habitat type at equilibrium (i.e., approximately at the conclusion of the 50-year planning horizon for the project) are shown in Table ES-2.

Tidal Pannes

Tidal pannes are landscape features that pond water at the upland perimeter of tidal wetlands in the San Francisco Estuary. These pannes will be constructed adjacent to the non-tidal habitats at final elevations of about +4.5 ft. The hydrologic regime in the tidal pannes will include: (1) year-round infrequent tidal inundation during the higher monthly tides (spring tides); and (2) seasonal freshwater inputs from direct rainfall and runoff from adjacent areas. Tidal pannes typically dry between spring tides during the summer and fall dry seasons and may remain inundated during some or all of the winter and spring rainy season depending on local precipitation. Consequently, surface water and soil salinities tend to vary from nearly fresh to hypersaline, resulting in environmental stresses that limit vegetation colonization. Because tidal pannes occupy the topographic transition between tidal marshes and non-tidal habitat, both the total acreage and actual location of tidal pannes will change over time due to settlement, subsidence, and sea level rise (compare the tidal panne locations in Figures ES-3, ES-4 and ES-5).

During the very high tides that flood these pannes, ducks and larger waders might forage in these areas. Shorebirds may find some prey in these areas, particularly after inundation by very high tides, although most of the use of this habitat type would be by roosting gulls and shorebirds during normal high tide, when their preferred foraging areas are inundated.

Tidal Marsh

Tidal marsh will be the dominant habitat and eventually extend over most of the Hamilton site over time (Figure ES-5). The tidal marsh plain consists of low, middle, and high vegetated marsh plus channels and interior tidal ponds (described in subsequent sections). The Natural Gradient alternative will involve construction of only the "template" (Figure ES-3) upon which natural processes will then act to create the tidal marsh over time. This template consists of an intertidal mudflat constructed of primarily fine-grained dredged material placed at elevations at least one foot below the elevation at which "low" marsh vegetation begins to colonize, construction of internal peninsulas on the HAAF portion to promote rapid sedimentation, and introduction of tidal action through breaching the existing outboard levee. Dredged material would be placed at elevations ranging from a maximum of +2.0 ft. around the site perimeter down to 0.0 ft. nearest the locations for the levee breaches.

Tidal marsh will form on this "template" in two ways. First, it will progress from the edges inward as vegetation colonizes from the site perimeter in bands of "high" marsh and "middle" marsh (see Table ES-1). This process will start soon after construction since the appropriate elevations will exist around the entire site perimeter. Second, tidal marsh will form in the interior areas as sediment accretion raises site elevations up to where "low" marsh plant species can begin to colonize and spread (see Table ES-1). This form of marsh establishment will begin a few years after return of tidal action, once enough sedimentation has occurred. Over time, a fully vegetated marsh plain will colonize the site with elevations ranging between MHW to about one foot above MHHW. A dense network of channels and numerous interior tidal ponds will be interspersed throughout the site (see Figure ES-5).

The tidal wetlands are expected to provide habitat for a number of bird species, including several threatened or endangered species dependent on salt marsh habitats including the California black rail, California clapper rail, San Pablo song sparrow, and salt marsh common yellowthroat. Large

numbers of raptors would also use the site, including the peregrine falcon, merlin, American kestrel, red-tailed hawk, northern harrier, and white-tailed kite.

The salt marsh harvest mouse, a state- and federal-endangered species, is expected to use salt marsh habitat dominated by pickleweed.

Channels

Slough channels in tidal marshes are the conduits through which tidal waters flow, carrying their load of sediment, nutrients, and aquatic organisms into and out of the marsh. Slough channels will form rapidly on the tidal mudflats. Channels will range in size from very large channels on the order of hundreds of feet in width that never empty completely to very small channels on the order of one foot or less in width that only are filled with water during higher tides. Formation of the medium and large slough channels will result in down-cutting into placed dredged material by tidal flows. Much of the eroded material will be redeposited elsewhere on the site, while some of the eroded material will be transported back into San Pablo Bay.

Slough channels can be either intertidal, in which case they drain at low tide, or subtidal, in which case they support open water at all times. Water depths and surface area vary continually throughout the rise and fall of the tides, thereby providing constantly changing environmental conditions. Channels thus support a diversity of ecological functions depending on channel size and tidal stage, ranging from shallow and deep open water areas to intertidal mudflats.

Channels within the restored tidal marsh system will greatly enhance the use of the area by fish entering from San Pablo Bay. A number of important game or commercial species would spend the early stages of their lives in such a tidal marsh, including Pacific herring, English sole, and striped bass. San Pablo Bay has been identified as designated critical habitat for the winter run of the Chinook salmon and fall-run Chinook salmon have been observed using the nearby Sonoma Baylands wetland restoration site.

Intertidal Mudflats

Intertidal mudflats will be the dominant habitat type initially and will gradually disappear as natural sedimentation raises the site to elevations suitable for tidal marsh vegetation colonization. Intertidal mudflat will initially extend over most of the tidal portions of the site (Figure ES-3) and will resemble the large mudflats with very gradual slopes found adjacent to Hamilton in San Pablo Bay. The sequence of evolution from intertidal mudflat to vegetated tidal marsh is described above. Intertidal mudflats will mostly be limited to the slough channels within the mature tidal marsh.

Mudflats typically support a high abundance of benthic organisms (i.e., the organisms that live in the mud and on its surface) that serve as a critical component of the food web of estuarine ecosystems. Numerous shorebirds are expected to feed on these benthic organisms at low tide primarily during migration and winter. A number of gulls are expected to forage in or around the marsh and mudflats as well, and Forster's and Caspian terns and ospreys would hunt for fish in offshore waters and marsh channels.

Subtidal Open Water

Subtidal open water areas support continuous open water throughout all tidal stages and exist where the elevations are below the Extreme Low Water (ELW) elevation. In the Natural Gradient

alternative, subtidal open water areas will initially be limited to the levee breach and pilot channel in the outboard marsh (see Section ES-4.2.1 below). Subtidal open water areas will then increase fairly rapidly as tidal flows scour large slough channels into the site from the levee breach (see Table ES-2).

Subtidal open water areas provide foraging habitat for migratory and resident waterfowl, as well as brown pelicans and cormorants. These areas would also likely benefit those fish species listed above for the tidal marsh.

Interior Tidal Ponds

Interior tidal ponds are landscape features of mature, equilibrium tidal marshes in the San Francisco Estuary and were historical features at Hamilton. Interior tidal ponds are located atop "drainage divides," or higher areas on the marsh plain between adjacent slough channels. These drainage divides are directly analogous to ridge lines that divide watersheds in upland settings except that the height of drainage divides in tidal marshes is on the order of inches. Interior tidal ponds will not be constructed but instead are expected to form through natural processes within the middle and high marsh plain.

Interior tidal ponds have three water sources. Most prevalent are tidal inputs, typically from higher spring tides. Direct rainfall and emergent groundwater also contribute to surface ponding, while water is lost by surface drainage, groundwater infiltration, and evaporation.

Interior tidal ponds provide foraging habitat for numerous species of shorebirds and waterfowl.

ES-4.1.2 Constructing the Natural Gradient Alternative

Principal Engineering Aspects

Flood Control Levee

The Natural Gradient alternative requires construction of a flood control levee around most of the site that will tie into the existing NHP levee (Figure ES-3). The flood control levee crest elevation will be constructed to +12 ft., based on the estimated 100-year high tide elevation of +7.0 ft., expected settlement of up to 3.5 ft., and an expected 0.5 ft. of sea level rise. .

Tidal Berms

Earthen berms, 100 ft. in width, will be constructed along the interior of the flood control levees in tidal areas to provide erosion protection and additional habitat. These berms begin along the flood control levee slope at an elevation of +6 ft. and slope down toward the tidal marsh to an elevation of +2 ft. Because they are located at intertidal elevations, the tidal berms will provide an early colonization site for tidal marsh vegetation and thereby speed the process of marsh establishment.

Internal Peninsulas

A system of internal peninsulas is proposed for the HAAF parcel as part of the site template to accomplish three objectives: (1) reduce flood control levee erosion by decreasing internal wave heights, thereby reducing wave runup; (2) promote rapid sedimentation by limiting internal wave energy; and (3) guide the location of deep tidal slough channels away from the flood control

levees and the wetlands covering the runway. The peninsulas will be separated from the site perimeter to limit predator access. Internal peninsulas will be located to provide a maximum fetch length of 3,000 ft. The location of the internal peninsulas are shown in Figure ES-3. Crest elevations will be +5 ft. with a top width of 10 ft. The peninsulas will be constructed with on-site borrow material and, if additional volumes are needed, with dredged material. The internal peninsulas are expected to have a 10-year design life, after which time sedimentation and vegetation colonization will have raised the surrounding marsh plain high enough so that the marsh rather than the peninsulas dampen internal wind waves. Over time as the peninsulas settle and subside into the tidal marsh, they will become high tide refugia within the middle and high marsh plains.

No internal peninsulas are proposed for the SLC parcel for three reasons. First, because the precise relationship of wind fetch length to limitations on marsh vegetation colonization is not certain, this project provides an opportunity to better evaluate this phenomenon. Second, the SLC parcel is smaller (250 acres) and its fetch distances are already within the 3,000 ft. range planned for the HAAF parcel. Finally, because the upper three feet of soil at the SLC parcel will be excavated for use as borrow material (see below), the peninsulas would have to be nearly 15 ft. tall to achieve the design crest elevation and would thus be difficult and expensive to construct. For these reasons, no internal peninsulas will be constructed on the SLC parcel and instead a tidal berm will be included adjacent to the flood control levee to protect it against erosion. The performance of the two parcels can be evaluated over time to improve our understanding of wind fetch processes on sedimentation and marsh vegetation colonization.

Levee Breaches and Pilot Channels

Two levee breaches are proposed, one for the HAAF site and another for the SLC site. Two breaches are needed because the outfall pipe alignment for the Novato Sanitary District currently bisects these two parcels and, unless the pipe is relocated, its protection requires the two parcels to be independent hydrologically (see Section ES-4.2.3 below). In addition to the levee breaches, pilot channels will be excavated through the outboard tidal marsh to provide unrestricted tidal exchange with San Pablo Bay. The pilot channels have been sited to cut through the narrowest portion of the outboard marsh in order to minimize impacts to this marsh. The dimensions of the levee breaches and pilot channels are presented in Table ES-4. The pilot channels will have the same depth as the levee breaches but will have narrower top widths in order to minimize construction impacts to the outboard marsh. Levee breach and pilot channel dimensions are sized for the equilibrium tidal prism, not the four times larger tidal prism when the levees are initially breached. This under-sizing is not expected to have adverse consequences on tidal exchange with San Pablo Bay nor on the evolution of the restored tidal marsh. Further analysis of the inlet dynamics is recommended for final design (see Section ES-7).

Lowering Outboard Levee

The existing outboard levee separating the HAAF and SLC parcels from San Pablo Bay will be lowered to varying elevations between +3.5 to + 5.0 ft. to provide high marsh and high tide refugia.

Borrow Materials

Borrow materials are required to construct the flood control levee and adjacent tidal berm (about 1.57 million cubic yards [mcy]), internal peninsulas (about 93,000 cy), and NSD outfall pipe protection levee (about 73,000 cy), for a total need of approximately 1.73 mcy. The project will generate about 1 mcy by excavating the upper 3 ft. of the SLC parcel. The remaining 0.73 mcy will come from several sources, including in descending order of preference: (1) adjacent or nearby clean borrow soils for the internal peninsulas, (2) using dredged material for the tidal berms adjacent to the flood control levee, (3) reusing existing levee material for the new flood control levee, (4) constructing the flood control levee initially to less than final design height and then using material gained from later construction activities such as the levee breach, pilot channel excavation and lowering of the outboard levee, (5) using additional surface soils from the HAAF parcel if suitable, and (6) importing construction fill. Preliminary analyses indicate that the range of available sources should provide adequate soil volumes for all the construction needs, without relying upon the costly import of construction fill.

Interior Channel Formation Relative to Existing Paved Surfaces

The internal peninsulas are designed in part to "steer" the location of larger tidal slough channels away from buried paved surfaces that might interfere with channel development. However, in one location, the buried runway would be up to 1 ft. higher than anticipated channel depths. This interference is not considered significant since the channel should be able to increase in width to accommodate expected tidal flows. Three other paved areas in the revetment area north of the runway would be up to three feet higher than the anticipated channel depths. In these locations, removal of the paved surfaces is recommended to allow natural slough channel formation.

Existing Infrastructure

NSD Pipeline and Dechlorination Facility

Relocation of the dechlorination facility to the NSD treatment plant is part of the Natural Gradient alternative. Two options are available to accommodate the NSD pipeline: (1) construct a new access levee between the HAAF and SLC parcels to protect the pipe and allow continued access by NSD personnel, which is the default configuration, or (2) truncate the outfall pipe so that it discharges directly into the restored wetland. This latter alternative would allow the HAAF and SLC parcels to become a single hydrologic unit with one rather than two levee breaches, which would be a preferred variation to the proposed design. Discussions are ongoing with NSD.

Drainage Facilities

Future drainage patterns following project completion will differ from the existing conditions. Rather than being collected in the perimeter drainage ditch and routed to the pump station at the northeast corner of HAAF to be pumped into San Pablo Bay, the inflows will gravity drain through the uplands and wetlands to San Pablo Bay through the levee breach. These changes will require reconstructing existing flap-gated culverts at new, higher elevations, installation of a small pump for part of the Landfill 26 drainage, and reconstruction of flap-gated culverts from Pacheco Pond. The plan assumes that the U.S. Army, as part of base closure, will address drainage of the adjacent Las Gallinas Valley Sanitary District and California Quartet/Bel Marin Keys Unit V properties.

Dredged Material Engineering

The Natural Gradient alternative will use dredged material to raise the site to final elevations in the non-tidal areas and to target elevations in the tidal areas. This design alternative can use a combination of sand and fine-grained dredged material or only fine-grained dredged material in order to accommodate the range of potential dredged material sources in the San Francisco Bay. All dredged material considered for use at Hamilton will have chemical concentrations and sediment toxicity below levels that could harm wetland biota.

Comparing Use of Sandy Versus Fine-Grained Dredged Material

Dredging projects in the San Francisco Bay produce a range of grain sizes in the material dredged, ranging from fine-grained bay muds to coarser sands. These different material types have several differences in their properties for constructing wetland restoration projects and for supporting wetland ecosystems. The design of the Natural Gradient alternative takes these properties into account in determining the location, elevations, and relative amounts of each type of dredged sediment.

The non-tidal habitats will be constructed with a thick foundation of sandy dredged material capped by one to two feet of fine-grained dredged material. The tidal habitats will be constructed primarily with fine-grained dredged material, though sandy dredged material foundation could be used in the deeper portions of the site.

Dredged Material Volumes

Volumes of needed dredged material were calculated separately for the non-tidal and tidal portions of the site. The Natural Gradient alternative proposes to use sand and fine-grained dredged material in the non-tidal areas. A total of approximately 1.8 mcy of sand would be placed as the lower and thicker layer, and approximately 0.3 mcy of fine-grained material would be placed on top of the sand to provide the substrate for the seasonal ponds and wetlands. Several questions remain regarding the long-term behavior of this combination of dredged material to achieve the desired ecological objectives; additional studies will be performed prior to completion of final design to investigate these issues.

The Natural Gradient alternative proposes to use primarily fine-grained dredged material for the tidal wetlands, with the possibility that sand would be placed first in the deeper areas at least 1 ft. below the final constructed surface. Assuming that only fine-grained dredged materials are used, the HAAF tidal wetland area could accept up to 5.0 mcy and the SLC tidal wetland area could accept another 3.5 mcy, for a total capacity of up to 8.5 mcy. The Natural Gradient design could also be constructed using lesser total quantities of dredged material, with the difference being a longer time for evolution of the tidal wetlands because of the increased volume of natural sedimentation required.

Dredged Material Potential Sources

Potential sources of dredged material include both maintenance and new work dredging projects. Potential sources of new work dredging project material include the Port of Oakland -50 ft. project, Southhampton Shoal, and Concord Naval Weapons Station. These projects together could supply up to 10 mcy of sandy material and 9 mcy of fine-grained material. Potential sources of maintenance dredging material include up to 18 projects based on probable timing,

location, dredging methods, material type, and material history. The average annual dredging volume of these 18 projects is 2.2 mcy, of which 1.7 mcy is fine grained and 0.5 mcy is sandy. Assuming a 3 to 5 year construction period for this project, between 6.6 and 11 mcy of maintenance dredged material could be available for Hamilton.

Dredged Material Offloading

Four options were considered for offloading dredged material at Hamilton: a deep water site, a shallow water site, dredging a deep water channel close to the site, and dredging a shallow water channel close to the site. The preferred alternative proposes that dredged material will be delivered by barge from the dredging locations, to an unloading pumpout facility located on a moored barge. A submerged pipeline will carry the dredged material in a slurry onto the site. The preferred approach is a deep water offloading facility sited in San Pablo Bay at -16 ft. MLLW, which would allow dredgers the maximum flexibility to use the largest available barges at all tidal stages. This deep water location would be 24,000 ft. from the site and would require booster pumps to move the slurry onto the site. A shallow water facility in San Pablo Bay at -8 ft. MLLW may also be located closer to the shore for use by smaller dredging projects, which would shorten the pumping distance to approximately 15,000 ft. These offloading facilities could be operated simultaneously to accommodate concurrent dredging projects. Options to dredge shallow or deep channels closer to the site were dropped from consideration because of the cost to dredge and maintain these channels.

Cost Estimate

The preliminary cost estimate for the Natural Gradient alternative considers two categories of costs: site preparation and dredged material placement. Site preparation costs include construction of the flood control levee, tidal berm, internal peninsulas, accommodation of the NSD pipeline and dechlorination facilities, levee breaches, outboard marsh pilot channels, relocation or removal of other utilities, seeding and planting, and any other grading needed. Not included in the cost estimate are demolition and removal of remaining structures at HAAF and SLC; it is assumed that the U.S. Army and others will complete these activities prior to property transfer. Site preparation costs are estimated at approximately $18 million. However, if the U. S. Congress designates Hamilton as a beneficial reuse site then 75 percent of these costs will be paid by the federal government (U.S. Army Corps of Engineers) and the remaining 25 percent would be the "local sponsor" cost share. Thus, the local sponsor cost would be $4.5 million.

Dredged material placement costs depend on a number of factors, including the relative proportions of sandy and fine-grained dredged material placed at the site. Costs also depend on the source of the dredged material (maintenance versus new work dredging) as it relates to the cost differential between placement at Hamilton and disposal at an in-bay location or the deep ocean site. This cost estimate assumes the total volume of dredged material needed to construct the site features is used. Dredged material placement costs attributable to the Hamilton project would range from approximately $14 million to $21 million. Because the larger dredging projects are co-sponsored by the federal government, if the U. S. Congress designates Hamilton as a beneficial reuse site then the 75 percent cost sharing described above will be paid by the federal government and the remaining 25 percent would be the local sponsor cost share. Thus, local sponsor costs would range between $3.5 million to $5.3 million.

The total project cost will therefore range from $32 million $39 million.

The local sponsor share would range from $6 million to $9.75 million.

ES-5.1 NATURAL SEDIMENTATION ALTERNATIVE

The Natural Sedimentation alternative is not the preferred alternative but would be implemented if no dredged material becomes available for wetland restoration. This alternative meets many of the project goals and objectives with the exceptions discussed below. This alternative would not use dredged material and instead would rely on natural sedimentation to raise the site to elevations suitable for tidal marsh establishment. Non-tidal areas could not be constructed at elevations above the limits of tidal influence because of the lack of fill material; consequently, an additional levee would be constructed across the southeastern limit of the panhandle area and managed perennial and seasonal ponds and wetlands would be created behind this new levee with the use of water control structures (Figure ES-6).

The major differences in the Natural Sedimentation alternative are:

- the 80/20 split of tidal and non-tidal habitat cannot be achieved (see Section ES-5.1)
- the non-tidal habitats are significantly different hydrologically and ecologically and do not include the transitional uplands and corridor areas (see Section ES-5.2)
- the non-tidal habitats would require active management in perpetuity
- no tidal pannes would be created
- the internal peninsulas would be located to achieve 2,000 ft. fetch lengths rather than the 3,000 ft. of the Natural Gradient alternative, to account for the greater water depths of the unfilled tidal portions of the site, and
- the timeline for establishment of tidal wetlands is longer (see Section ES-6.0).
- the cost of constructing the project would be approximately $15 million.

The remaining project components are identical to the Natural Gradient alternative and thus are not described here.

ES-5.1.1 Mix of Tidal and Non-Tidal Habitat

The Natural Sedimentation alternative does not use dredged material to raise site elevations above tidal influence, therefore it is limited in its ability to establish non-tidal habitat. Instead of the target of 80 percent tidal and 20 percent non-tidal habitat that the HRG established, the Natural Sedimentation alternative provides approximately 92 percent tidal wetlands and 8 percent non-tidal managed seasonal ponds and wetlands and perennial open water and emergent marsh.

ES-5.1.2 Description of the Non-Tidal Habitat

Under the Natural Sedimentation alternative, the non-tidal habitats would be constructed at existing grade behind a "cross panhandle" levee fitted with water control structures. The water supply for these areas would be rainfall, freshwater inputs from Landfill 26, one of the NHP outfalls, and Pacheco Pond and controlled tidal flows through a gated culvert. Storm outflows into the tidal wetland would occur by gravity drainage during low tide through separate flap-

gated culverts (see Figure ES-6). Because no dredged material would be used in this alternative, no uplands and wildlife corridor areas would be created and thus there would not be a "natural gradient" from the upland to tidal portions of the site; instead, the restored wetlands would end abruptly at the levees. The non-tidal wetlands would be largely perennial emergent marsh and open water areas rather than the goal of mainly seasonal ponds and wetlands.

The seasonal wetland and fully aquatic habitats created in this alternative will have variable salinities. The dominant plant species in this system will be salt-tolerant plants that will reach their maximum productivity from early spring to late summer. Plant species that will likely be found in the saline seasonal wetlands include salt grass, pickleweed, fat-hen (*Atriplex triangularis*), brass buttons (*Cotula coronopifolia*), gumplant (*Grindelia humilus*), alkali bulrush (*Scirpus maritumus),* and alkali heath.

The diversity and types of wildlife species occurring in these habitats would depend in large part on the extent of the habitats, the depth and extent of water, and the type and amount of vegetation present. The presence of shallow water, even on a seasonal basis, would provide suitable foraging habitat for many shorebirds (especially during high tide, when tidal mudflats are inundated), gulls, waders, and dabbling ducks. If salt marsh vegetation (such as pickleweed, salt grass, or gumplant) is well developed, then bird species such as the savannah sparrow or song sparrow might nest in these habitats. Black rails might nest in the seasonal wetlands adjacent to broader pickleweed tidal marshes. Salt marsh harvest mice are expected to occur in seasonal wetlands if sufficient cover of pickleweed is present. If grasses dominate, then more upland mammals (e.g., western harvest mice, deer mice, and California voles) would be expected to occur.

ES-6.1 TIMELINE FOR TIDAL WETLAND RESTORATION

Both project alternatives rely on natural sedimentation to raise the tidal portions of the site to marsh plain elevations. Because no dredged material will be used, no tidal pannes will be constructed as part of the Natural Sedimentation alternative. The Natural Sedimentation alternative begins at existing site elevations, which average -5 ft. at the HAAF site and -8 ft. at the SLC (after excavating the upper 3 ft. of soils as borrow material). However, the Natural Gradient alternative establishes initial site elevations at 0 to +2 ft. through placement of dredged material. The major differences between the two alternatives for establishing tidal marsh, then, are (1) the total amount of natural sedimentation needed and thus the elapsed time required to fill the site and (2) the time needed to place dredged material.

Sedimentation rates are a function of (1) the suspended sediment supply in the inflowing tidal waters, which varies seasonally and from year to year, (2) site elevations, with higher elevations having less tidal inundation and thus less opportunity for sediments to deposit, and (3) sediment resuspension due to wind waves and tidal flows.

To predict the time required to reach marsh plain elevations, a brief analysis was performed relating expected sedimentation rates to site elevations. Prediction of long-term sedimentation rates is difficult and uncertain. Thus, the analysis generated a range of time to reach target elevations based on a range of expected sediment concentrations. Two ecologically meaningful target elevations were considered: MHW, which is the upper elevation for cordgrass-dominated low marsh and the lower elevation for pickleweed-dominated middle marsh, and MHHW, which is the upper elevation for middle marsh and the lower elevation for high marsh comprised of a mixture of salt-tolerant plant species. Finally, the analysis included an assumption that the outboard levee would be breached four years later under the Natural Gradient alternative, which is the expected upper limit of time to place the dredged material.

Combining these factors of estimated construction time with the expected sedimentation rates, the anticipated time required to reach the MHW and MHHW elevations on average are presented in Table ES-5. Because the estimates have a margin of error of at least five years, all times are rounded to the nearest five-year increments. Near the tidal inlet (termed the "front marsh" in Table ES-5), the Natural Gradient alternative accelerates reaching the MHW average elevation from between no difference to five years, and the MHHW average elevation from between no difference to ten years, relative to the Natural Sedimentation alternative. Away from the tidal inlet (termed the "back marsh" in Table ES-5), the Natural Gradient alternative accelerates reaching the MHW average elevation from between five and ten years, and the MHHW average elevation from between five and fifteen years, relative to the Natural Sedimentation alternative. These results are shown as a comparative project timeline in Figure ES-7.

ES-7.1 CONSIDERATIONS FOR FUTURE STUDY

Additional Information Needs Related to Base Closure, Novato Sanitary District Facilities, and Adjacent Properties

Following is a listing of further studies that are desirable to clarify issues related to the Hamilton Wetlands Restoration project.

- It is necessary to know how the Army base closure and transfer process plans to resolve issues of contaminants on site and the availability of clean fill material onsite. This information will affect quantity and cost estimates for levee, peninsula. and tidal berm construction.
- It is necessary to know how the Army base closure and transfer process plans to resolve the perimeter drainage issues, in particular flow from adjacent areas.
- A feasibility study of options for resolving issues related to the Novato Sanitary District's dechlorination station and outfall line is needed. It should include an assessment of the ramifications of levee and internal berm construction above and adjacent to the existing pipeline, and the potential advantages of having the pipeline discharge to the site.
- The SLC site wetlands delineation needs to be quantified.
- Including the portion of the GSA Phase II property between Landfill 26 and the seasonal wetlands in the project needs to be considered to make the area topographically and hydrologically contiguous and functionally integrated and omit the flood control levee in that area
- There is a need for further investigation into regional opportunities to expand the restoration area to include the California Quartet Bel Marin Keys Unit V parcel.
- Further investigation and coordination with the NHP is required to define the acceptable methods and elevations for material placement on and adjacent to the NHP's levee, so that settlements of the levee and of nearby structures are not significantly impacted.

Wetland Design Development Studies

Following is a listing of additional studies that are needed to be implemented to refine the conceptual designs and performance estimates included in this report.

- Conduct site-specific geotechnical investigations to establish the basis for final levee design.
- Conduct field investigations at other wetland sites to evaluate levee performance in regard to stability, settlement and scour/erosion.
- Once the specific dredging projects (at least the major contributors) supplying material to this project have been identified, evaluate and decide on the potential off-loader locations and the contracting methods for material off-loading and placement.
- Refine estimates of the time frame for tidal wetlands evolution by:

  - Conducting detailed hydrodynamic and sediment transport modeling to refine the estimates of the rate and distribution of sedimentation
  - Gathering additional existing data and conducting field monitoring-to refine estimates of suspended sediment supply to the tidal wetlands
  - Conducting field investigations at several reference tidal marshes created using dredged materials
  - Conducting field investigations of other restored tidal marshes to assess vegetation colonization rates
- Conduct field investigations at several reference San Francisco Bay tidal marshes created using dredged materials to optimize the target fill elevations.
- Refine the internal peninsula design based on further investigation of wind-wave impacts on sedimentation rates, vegetation colonization rates, and peninsula erosion and subsidence.
- Evaluate the expected persistence of the internal peninsulas using field reconnaissance at other wetland locations.
- Conduct detailed hydrodynamic modeling of inlet dynamics to characterize the potential for scour in and adjacent to the inlet.
- Conduct field surveys of other wetland locations and geomorphic analysis to assess the evolution of the tidal wetland inlet channel across the marsh and mudflat.
- Characterize the effects of removing some or all of the outboard levee on wave action, flooding, and wetland development.
- Conduct field surveys to observe vegetation and hydrologic characteristics of analogous seasonal wetlands created on sand and dredged Bay Mud substrates in order to refine the seasonal wetlands design. The design of the upper layers of the seasonal wetlands fill will require further analysis to define the material type and placement requirements that will result in acceptable permeability and ponding characteristics.
- Conduct field surveys to observe the topography, hydrology, and salinity of reference tidal pannes in order to refine the tidal panne design.
- Specify design features (invert elevation, flow capacity, etc.) for the hydraulic control structure(s) between Pacheco Pond and the panhandle necessary to mitigate for potential flood impacts and/or improve Pacheco Pond flood conditions.
- The results of the Section 204 Study of the Hamilton Project by the U.S. Army Corps of Engineers, San Francisco District should be considered and/or incorporated into subsequent and final project designs.
- During subsequent project investigations and the final design the dredged material supplies for the project need further detailed evaluation, planning and coordination.

Table ES-1 Target Habitats

Habitat	Typical Flora	Typical Animals	Typical Birds	Special Status Species	Potential Nuisance Species	Elevation Range	Water Source	Frequency of Inundation
Upland	Annual & perennial grasses (including *Leymus triticoides*), forbs, shrubs	Mule deer, jack rabbit, California vole, broad-handed mole, lizards, snakes, fox, raccoon, striped skunk	raptors, sparrows, warblers, mourning dove, Anna's hummingbird, finches, California towhee	Burrowing owl, loggerhead shrike, northern harrier	Trees would threaten levee integrity	above 7 ft (100 year high tide)	Precipitation, localized runoff & drainage	No standing water
Seasonal Wetland	Unvegetated areas interspersed with grasses, rushes, bulrushes, forbs, cattail, pickleweed	Pacific treefrog, common garter snake, gopher snake, Botta's pocket gopher, gray fox, coyote, raccoon, aquatic invertebrates	shorebirds, dabbling ducks, wading birds, raptors, passerines	Salt sarsh common yellowthroat, northern harrier	A monoculture covering the entire area would be undesirable. Feral cats, unleashed dogs, red fox.	above 5 ft. (above representative spring tide)	Precipitation, localized runoff & drainage, estuary	Seasonal, infrequently with extreme tides or tides coupled with storm surge.
Tidal Panne	Primarily unvegetated, seasonal algae	Aquatic invertebrates, minimal use by mammals, reptiles and amphibians, due to lack of cover	primarily shorebirds and gulls, occasionally ducks and wading birds	Salt marsh bird's beak (at edges), western snowy plover, California least tern		4.5 ft. (representative spring tide)	Precipitation and tidal flooding from estuary	Seasonal, with spring tides and other extreme tidal events
Tidal Marsh Ponds	Unvegetated	Copepods, cladocera, small fish	shorebirds, dabbling ducks, wading birds			approx. 3 to 4 ft.	Precipitation and tidal flooding from estuary	Normally inundated, can dry in summer between spring tides
Tidal Marsh	Low marsh: cordgrass Mid-marsh: pickleweed High marsh: salt grass, gum plant	Common garter snake, gopher snake, western harvest mouse, deer mouse, California vole	Rails, marsh wren, sparrows, raptors	California clapper rail, black rail, salt marsh harvest mouse, San Pablo song sparrow, salt marsh common yellowthroat, peregrine falcon	Perennial pepperweed in high marsh and East Coast cord grass in low marsh. Asiatic clam and mitten crab.	Low marsh: MT (0.61ft) to MHW (2.86 ft.) Mid-marsh: MHW to MHHW (3.43 ft.) High Marsh: MHHW to 4.5 ft.	Estuary	Low marsh: twice daily tidal action Mid-marsh: at least daily high tide High Marsh: monthly spring tides
Intertidal Mudflats	Algae	Polychaetes, amphipods, snails, clams, fish (when inundated)	Dunlin, plovers, sandpipers, dowitchers, yellowlegs, long-billed curlew, willet, marbled godwit, ducks (when inundated)		Asiatic clam	MT (0.61 ft) to MLLW (-2.63 ft)	Estuary	Daily tidal cycle
Channels and Subtidal	Channels: may have fringe of cordgrass or bulrush Subtidal: algae, eel grass	Shrimp, planktonic and benthic invertebrates, fish	Diving ducks, pelicans, cormorant	California brown pelican, Sacramento splittail, striped bass, green sturgeon, Chinook salmon, steelhead trout	Non-native fish species and invertebrates	Channels: MHHW to ELW Subtidal: Below ELW	Estuary	Channels: daily tidal cycle Subtidal: permanently submerged

(1) MT = mean tide, MHW = mean high water, MHHW = mean higher high water, MLLW=mean lower low water, ELW=extreme low water

Table ES-2
ESTIMATED EQUILIBRIUM TIDAL WETLAND HABITAT TYPES

Channel Characteristics	Channel Order					Total
	1	2	3	4	5	
HAAF Site						
Total Length of Channels (ft)	141,109	46,046	13,148	4,597	1,300	206,200
Average top width at MHHW (ft)	2	6	22	80	269	--
Average Depth below MHHW (ft)	1.0	3.2	8.0	10.5	11.8	--
Subtidal Habitat (acres)	-	-	5.8	8.2	7.9	21.9
Intertidal Habitat (acres)	6.5	6.3	0.8	0.3	0.1	14.0
Marsh plain (acres)	--	--	--	--	--	376.5
SLC Site						
Total Length of Channels (ft)	65,974	26,035	8,990	3,801	1,300	106,100
Average top width at MHHW (ft)	2	6	22	80	200	--
Average Depth below MHHW (ft)	1.0	3.2	8.0	10.5	9.9	--
Subtidal Habitat (acres)	-	-	4.0	6.7	5.9	16.6
Intertidal Habitat (acres)	3.0	3.6	0.6	0.2	0.1	7.5
Marsh plain (acres)	--	--	--	--	--	188.1

Note: Calculations assume a total drainage density of 500 feet/acre and constant bifurcation ratio. The inlet channel length is not included in the subtidal channel acreage.

Table ES-3
TIDAL CHARACTERISTICS AT HAMILTON ARMY AIRFIELD

(based on Petaluma River Entrance Tide Gauge #941-5252)

	NGVD Datum (feet)	MLLW Datum (feet)
100-year high tide	7.00	9.63
10-year high tide	6.00	8.63
Mean highest annual tide	4.68	7.31
Mean Higher High Water (MHHW)	3.43	6.06
Mean High Water (MHW)	2.86	5.49
Mean Tide Level (MTL)	0.61	3.24
Mean Low Water (MLW)	-1.63	1.00
Mean Lower Low Water (MLLW)	-2.63	0.00

Note: NGVD is mean sea level of 1929. Tidal terms are defined in Appendix B.

Sources: USACE SFD (1984), Tides and Currents tide prediction software, and National Oceanic and Atmospheric Administration (NOAA) tidal benchmark data.

Table ES-4
INITIAL TIDAL WETLAND INLET DIMENSIONS

	HAAF Site Inlet Dimensions		SLC Site Inlet Dimensions	
	Levee Breach	Outboard Marsh Pilot Channel	Levee Breach	Outboard Marsh Pilot Channel
Cross-Sectional Area (ft^2)	2,500	1,600	1,200	800
Channel Depth (ft, bottom elevation)	- 8.5	-8.5	-5.5	-5.5
Channel Top Width (ft)	280	165	220	100
Channel Bottom Width (ft)	155	40	120	20
Channel Side Slope (H:L)	1:4	1:5 - 1:10	1:4	1:5 - 1:10
Channel Length (ft)	200	800	50	200
Channel Excavation Volume (yd^3)	25,500	24,900	7,900	3,400
Channel Surface Area (acres)	1.3	3.0	0.5	0.6

Table ES-5
TIME (YEARS) REQUIRED FOR SEDIMENTATION TO REACH AVERAGE TIDAL PLAIN ELEVATIONS[a]

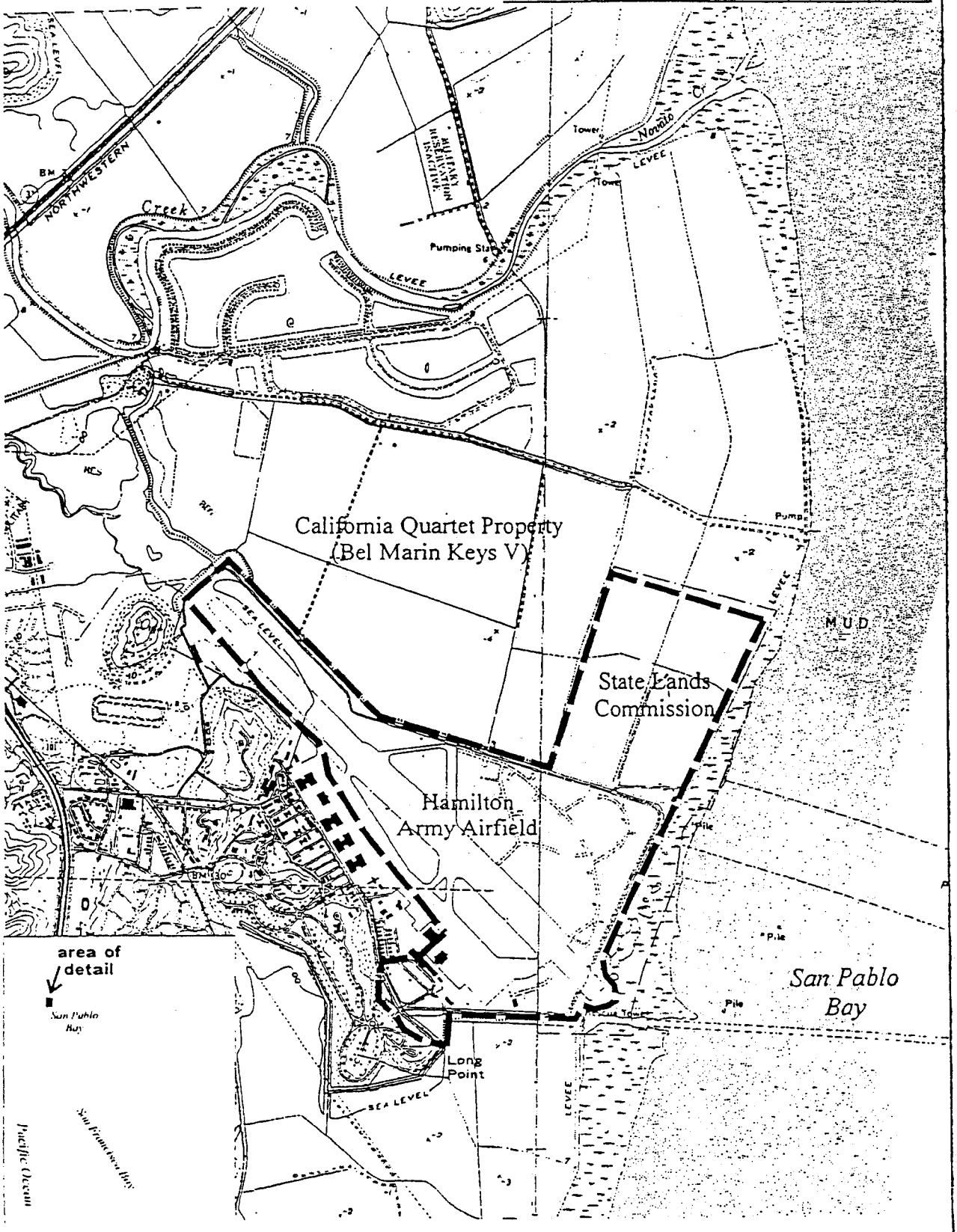
	Natural Gradient Alternative for HAAF and SLC[b]		Natural Sedimentation Alternative[a] for Front Marsh HAAF[d]		Natural Sedimentation Alternative[c] for Back Marsh HAAF[e] and SLC[f]	
	200 mg/l	350 mg/l	200 mg/l	350 mg/l	200 mg/l	350 mg/l
1. Years After Breach Outboard Levee (based on expected sedimentation rates)						
MHW	15	5	25	10	30	15
MHHW	25	10	40	15	45	20
2. Years After Start Project (reflects actual construction times shown in Figure 7-1)						
MHW	22	12	28	13	33	18
MHHW	32	17	43	18	48	23
3. Amount of Time Saved to Reach Target Elevations with natural gradient alternative relative to natural sedimentation alternative (years in #2 above for natural sedimentation minus natural gradient, rounded to nearest five years)						
MHW	na	na	5 (28-22)	0 (13-12)	10 (33-22)	5 (18-13)
MHHW	na	na	10 (43-32)	0 (18-17)	15 (48-32)	5 (23-18)

(a) = Estimated times are rounded to the nearest 5 year mark
(b) = Assumed average starting elevation of +1 foot
(c) = Assumed average starting elevation of -5 feet. HAAF
(d) = Front marsh is wetland areas closest to inlet
(e) = Back marsh is wetland area furthest from the tidal inlet (see Figure 5-5)
(f) = SLC starting elevation at -8

figure ES-1

Hamilton Wetland Restoration

Regional and Site Location Map



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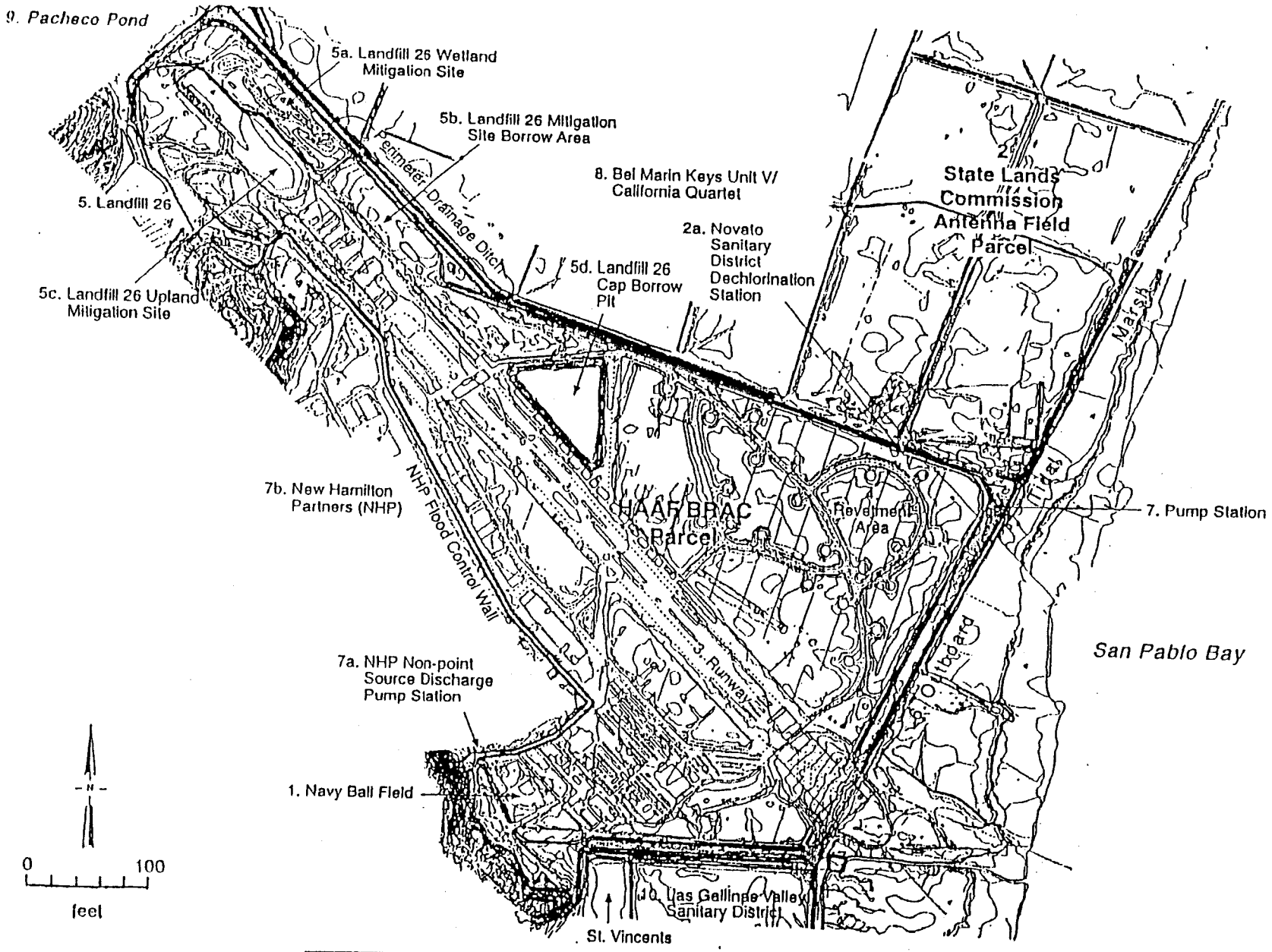
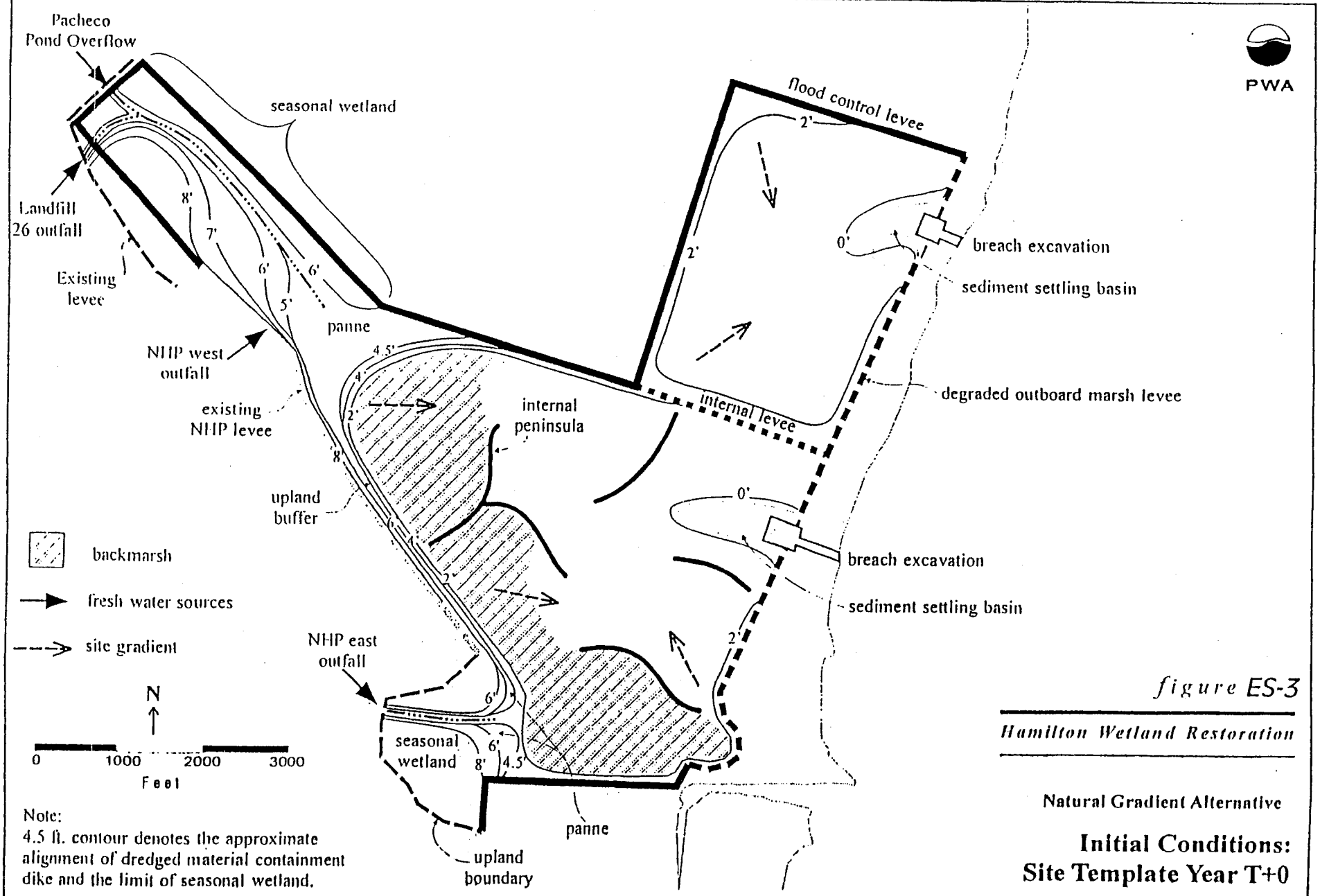


Project No. 971185NA	Hamilton Hamilton Wetlands Conceptual Plan	SITE PLAN	Figure ES-2
Woodward-Clyde			

971185NA-22DO/0-103



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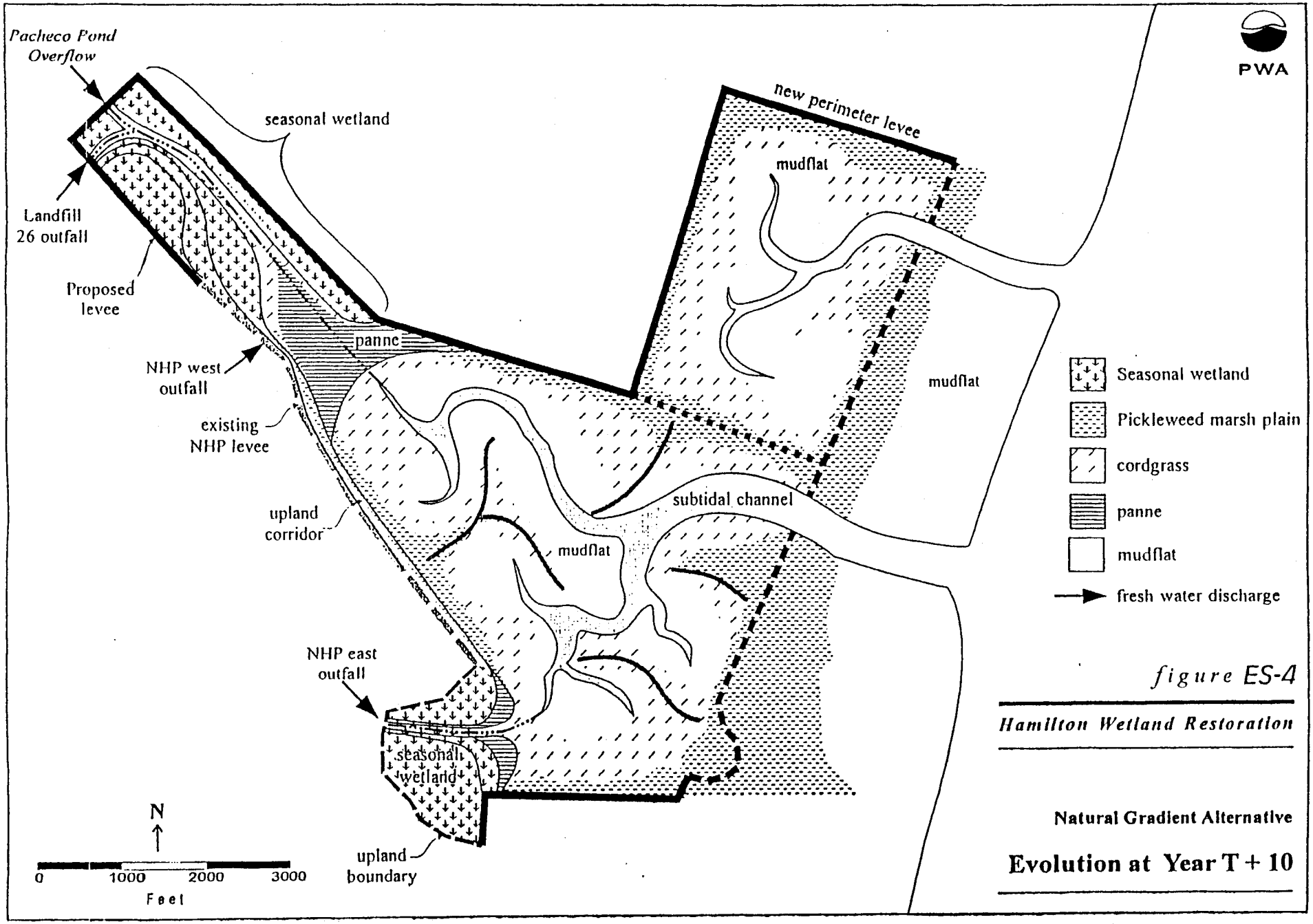

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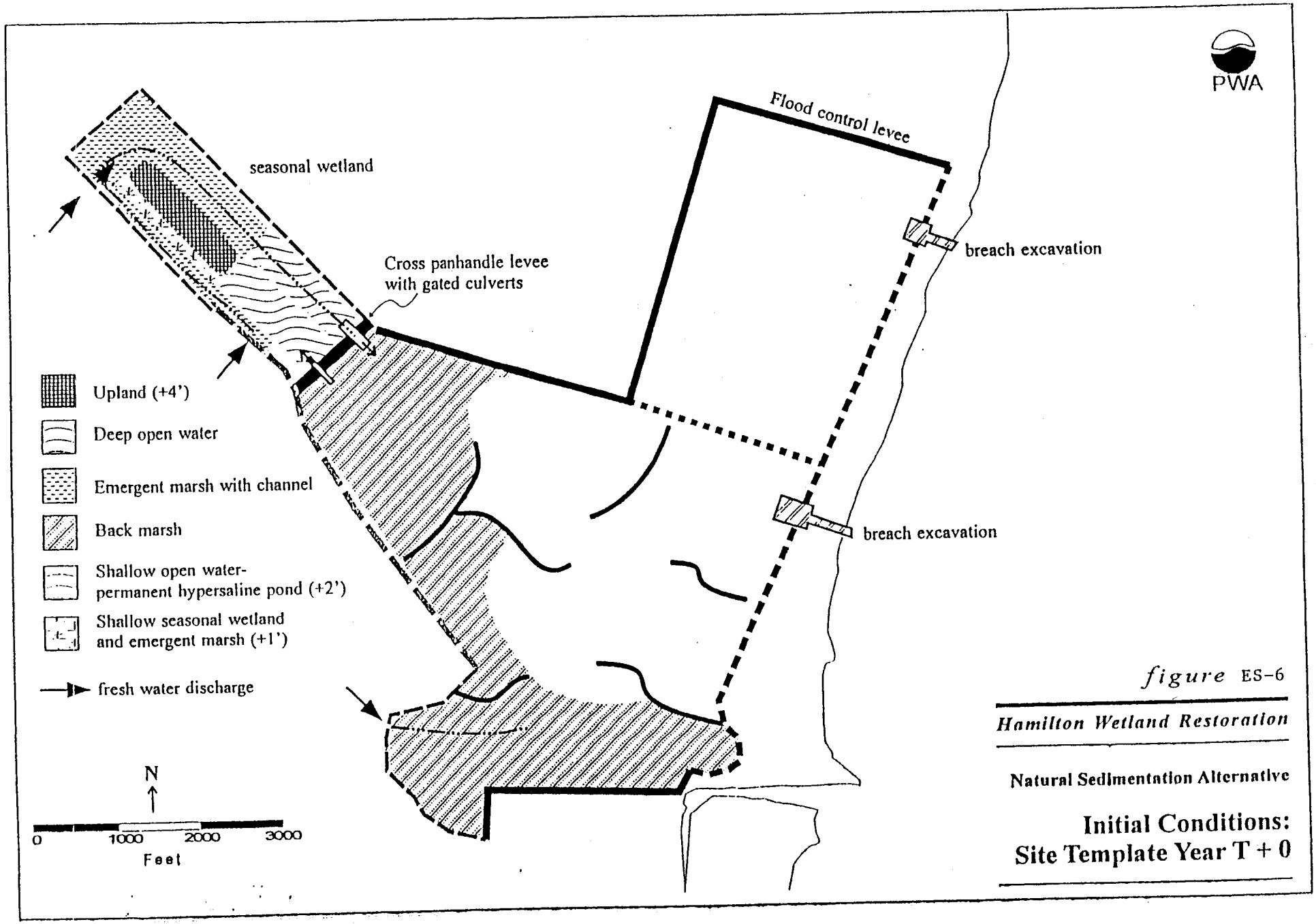

figure ES-6

Hamilton Wetland Restoration

Natural Sedimentation Alternative

Initial Conditions:
Site Template Year T + 0

Hm5.cdr 2.10.98

DRAFT